SOLID STATE IMAGE PICKUP ELEMENT AND METHOD OF MANUFACTURING SOLID STATE IMAGE PICKUP ELEMENT

BACKGROUND OF THE INVENTION

5   Field of the Invention

The present invention relates to a solid state image pickup element having a color filter for picking up a color image, and to a method of manufacturing a solid state image pickup element.

10   Related Background Art

Fig. 8 shows one of the structures, which have been known, as solid state image pickup elements, for use in color video cameras and color still cameras.

Fig. 8 is a side sectional view showing the

15   structure of a conventional solid state image pickup element.

The solid state image pickup element shown in Fig. 8 has, in the vicinity of a surface of a semiconductor substrate 100, a photoelectric

20   conversion portion 110 which generates signal charges according to the amount of incident light. The photoelectric conversion portion 110 is provided in each of pixels that are arranged to form a lattice pattern.

25   The pixels each have a driver circuit for generating a pixel signal in accordance with a signal charge that is generated in the photoelectric

conversion portion 110, and for sending the pixel signal to a horizontal scanning circuit (not shown in the drawing) in response to a control signal sent from a vertical scanning circuit (not shown in the

5   drawing) that is provided on an edge of the solid state photoelectric conversion element.

As shown in Fig. 8, gate electrodes 109 of transistors that constitute the above driver circuit are formed on the semiconductor substrate 100. On

10   the gate electrodes 109, wiring layers are formed to suit the circuit structure of the driver circuit. In the structural example shown in Fig. 8, two wiring layers 105 and 107 are formed. Diffusion layers (not shown) which serve as sources and drains of the

15   transistors are formed on portions of the semiconductor substrate that are under the gate electrodes.

Wires patterned to have a desired shape are formed in the wiring layers using aluminum (Al) or

20   the like. Interlayer insulating films 106 and 108 formed from, for example, SiO_2, are interposed between the wiring layers for insulation.

A first planarization film 104 is formed from, for example, acrylic resin, on the topmost wiring

25   layer 105, covering the wires of the wiring layer 105. Provided on the first planarization film 104 are color filters 103 for splitting incident light in

accordance with the color of a pixel. The color
filters 103 are classified into three types by their
colors (three primary colors of light): red (R) color
filters formed from photo resist that contains a red

5   pigment, green (G) color filters formed from photo
resist that contains a green pigment, and blue (B)
color filters formed from photo resist that contains
a blue pigment. Each pixel is covered with one of
the three types of color filters.

10   On the color filters 103, a light-transmissive
second planarization film 102 is formed and
microlenses 101 which are condensers for collecting
incident light in the photoelectric conversion
portion 110 are formed on the second planarization

15   film 102.

         Figs. 9A to 9D are side sectional views
illustrating a procedure of forming the conventional
color filters that are shown in Fig. 8.

         To form the color filters shown in Fig. 8,

20   first, negative color resist with, for example, a
green (G) pigment dispersed therein is applied to a
surface of the first planarization film 104. Then a
mask which blocks light except where green color
filters (hereinafter referred to as G filters) are to

25   be formed is placed for irradiation with ultraviolet
rays having a wavelength of, for example, 365 nm, and
for subsequent development. Thus G filters 103G are

formed on the first planarization film as shown in
Fig. 9A. The pattern of the G filters 103G measures
9.0 μm at the bottom portion (on the side of the
first planarization film 104).

5   Next, as shown in Fig. 9B, negative color
resist 103A with a red (R) pigment dispersed therein
is applied to the entire top surface of the first
planarization film 104 while covering the G filters
103G. Then a mask which blocks light except where

10   red color filters (hereinafter referred to as R
filters) are to be formed is placed for irradiation
with ultraviolet rays having a wavelength of, for
example, 365 nm.

       At this point, in a conventional method of

15   manufacturing a solid state image pickup element, a
mask having a transmissive portion with a width of
9.0 μm, which is equal to the width of a region
surrounded by the G filters 103G, is used in the
ultraviolet irradiation (see Fig. 9B) and subsequent

20   development to form an R filter 103R. In this case,
the R filter 103R rises at its edges where the R
filter meets the G filters 103G as shown in Fig. 9C.
Furthermore, as the ultraviolet irradiation energy is
increased, the edges of the R filter 103R climb over

25   the edges of the G filters 103G as shown in Fig. 9D.
In some conventional solid state image pickup element
manufacturing methods, a mask having a transmissive

portion that is slightly narrower than the width of the region surrounded by the G filters is used in ultraviolet irradiation to form the R filter 103R.

Details about how other components than the color filters are manufactured are omitted from the description here since they are irrelevant to characteristics of the present invention. Any known manufacture methods can be used to form other components than color filters as long as the optimal configuration is obtained for each of the other components.

In a solid state image pickup element having a large chip size, an image pickup region including the above vertical scanning circuit and horizontal scanning circuit is larger than the range that can be exposed to light in one shot of an exposure device (field size). Therefore, a split exposure method is employed in which the image pickup region is divided into plural exposure regions and the patterns obtained by the division are patched together to form a desired image pickup region. This method is described in JP 05-6849 A, for example.

Recent solid state image pickup elements suffer from various kinds of production fluctuation (such as mask size differences, microlens distortion components, exposure light distribution in one shot, mask alignment precision, and changes with time of

resist characteristics) due to the increased level of pixel integration. Such production fluctuation causes fluctuation in size and shape of color filters or mispositioning of color filters, with the result

5   that adjacent color filters overlap each other or a void is created between adjacent color filters.

In the solid state image pickup element manufacturing method described above, corners of the color filters are rounded because of lowering of the

10 resolution of the exposure device, and a void where no color filters are formed is also created in such corners. Adjacent color filters overlap each other also when the energy of ultraviolet irradiation used in exposure of color resist is larger than necessary

15 as described above and when the distance between adjacent color filters actually formed is shorter than designed. An example of eliminating such color filter overlapping and filterless void is disclosed in JP 10-209410 A. According to the method disclosed

20 in this publication, a void between adjacent color filters is eliminated by forming three types of color filters on top of one another and then removing the upper layer color filters until the lowermost color filter is exposed.

25 As mentioned above, photolithography is usually employed in manufacturing color filters of solid state image pickup elements. In recent solid state

image pickup elements where the pixel width is on the order of a few micron meters, a reduction projection exposure device called a stepper is also used to expose patterns of color filters to light in order to

5   accurately form such small pixels.

If there is fluctuation in production process or mispositioning of a mask in forming color filters, the size and position of the color filters are varied depending on the degree of fluctuation. As a result,

10   the shape and size of the color filters, the width of a void between color filters, and the color filter overlapping amount are varied from one exposure shot to another. Even when a mask having a transmissive portion that is narrower than the width of a region

15   surrounded by G filters is used in the above ultraviolet irradiation to form an R filter, the size and position of the R filter are varied due to fluctuation in production process and mispositioning of masks. Accordingly, the width of a void between

20   color filters and the color filter overlapping amount change so as to form distributions throughout the exposure shot plane, or are varied from one exposure shot to another.

A common solid state image pickup element has a

25   chip size smaller than the field size of an exposure device and therefore a color filter pattern is formed in one exposure operation. In this case, if there

are a void between color filters and overlapping of color filters as described above, the void width and the overlapping amount change continuously and two-dimensionally throughout the chip plane. Therefore,
5   the amount of light that enters the photoelectric conversion portion changes in a manner that forms a two-dimensional distribution in the image pickup region. This means that a pixel signal outputted contains a shading component and a color mixture
10   component corresponding to the void width and the overlapping amount, thereby causing degradation of a picked-up image.

     In a solid state image pickup element formed by the above-described split exposure method, the size
15   and position of color filters are varied from one exposure region obtained by the division to another exposure region. Therefore, it is very difficult to give color filters of different exposure regions the same size as well as to align a color filter of one
20   exposure region identically to a color filter of another exposure region.

     Light from an image pickup object enters a microlens formed on a surface of a solid state image pickup element through a light path indicated by a or
25   b in Fig. 10, for example. Here, a ray a is transmitted through the microlens, a first planarization layer, a second planarization layer, a

color filter, and several interlayer insulating films
to reach a photoelectric conversion portion. On the
other hand, a ray b enters from the interface between
pixels and, after being scattered, reflected,

5   refracted, diffracted and the like in the interface
between color filters and in wiring layers, some
components of the ray b reach the photoelectric
conversion portion.

When there is a void in the interface between

10   color filters, the absolute amount of incident light
is about three times larger than when the interface
has no void. Accordingly, if the void width varies,
the amount of light that reaches the photoelectric
conversion portion is varied by scattering,

15   reflection, refraction, diffraction and the like.
Furthermore, overlapping of adjacent color filters
and a void between adjacent color filters give the
second planarization film formed on the color filters
insufficient levelness, and surface irregularities

20   are created in the second planarization film above
the color filter overlapping portion and the color
filter void portion.

For instance, a concave portion in the second
planarization film above the color filter void

25   portion acts like a lens to disperse incident light
as shown in Fig. 11A. As a result, dispersed light
reaches the photoelectric conversion portion through

color filters and causes fluctuation in amount of
incident light among pixels.

In the color filter overlapping portion, on the
other hand, light passes through the combined

5   thicknesses of two color filters and is attenuated in
the process before reaching the photoelectric
conversion portion, resulting in fluctuation in
amount of incident light among pixels. In addition,
color is mixed as light passes through the color

10   filter overlapping portion since adjacent color
filters usually have different colors, and light of
mixed colors reaches the photoelectric conversion
portion. Furthermore, a convex portion formed in the
second planarization film above the color filter

15   overlapping portion as shown in Fig. 11B causes a
change in amount of light that enters the
photoelectric conversion portion indirectly through
refraction of light. Therefore, despite equal
conditions under which light from an image pickup

20   object enters pixels, the absolute amount of light
that reaches the photoelectric conversion portion
varies from one pixel to another.

When color filters are formed by the above-
described split exposure method, the color filter

25   overlapping amount and the void width are varied
among exposure regions divided as shown in Fig. 12 or
Fig. 13 (a first exposure region and a second

exposure region). This fact is reflected on difference in pixel signal voltage value (light detection sensitivity), which is determined by the amount of incident light, between the exposure

5   regions and the difference is erroneously recognized as a difference in brightness of the picked-up image. As a result, when a solid state image pickup element formed by the split exposure method is used in picking up an image, visible streaks of image non-

10   uniformity are found in portions of the picked-up image that correspond to interfaces between divided exposure regions.

Overlapping of color filters and a void between color filters are caused mainly by the exposure

15   process as described above. Therefore, the overlapping amount and the void width can be reduced by various measures such as raising the precision of the size of masks used in exposure to light, correcting mispositioning of masks, correcting the

20   exposure energy difference between exposure regions, and uniformizing characteristics of resist for forming color filters. However, it is impossible to reduce process fluctuation in an exposure region, namely, in-plane distribution, to nil. In addition,

25   exposure process differences between exposure regions cannot be eradicated as long as the split exposure method above is employed. It has therefore been

difficult in prior art to restrain within a certain
range the difference in light detection sensitivity
between exposure regions.

5   SUMMARY OF THE INVENTION

The present invention has been made to solve
the above-described problems of prior art, and an
object of the present invention is therefore to
provide a solid state image pickup element

10   manufacturing method and a solid state image pickup
element which can exponentially reduce the in-plane
photoelectric conversion portion characteristic
distribution that is created in forming color filters
by a common photolithography technique and which,

15   when color filters are formed by split exposure, can
reduce image non-uniformity between exposure regions
in a picked-up image.

To achieve the above-described object, the
present invention provides a method of manufacturing

20   a solid state image pickup element with negative type
color filters of plural colors formed of color resist,
including:

applying color resist for forming first color
filters onto an entire surface of a given film;

25   forming the first color filters by irradiation
of given portions with exposure light and by
subsequent development;

applying color resist for forming second color

filters to the entire surface of the first color

filters while covering the first color filters; and

forming the second color filters by irradiation

5   of an area smaller than a region that is surrounded

by the first color filters with exposure light and by

subsequent development.

In the solid state image pickup element

manufacturing method described above, exposure

10   conditions under which the second color filters are

exposed to light are altered from standard exposure

conditions to thereby widen a pattern of the second

color filters. Accordingly, a color filter can be

formed stably with its size and position regulated by

15   the sizes of adjacent color filters and no void is

created even when there is fluctuation in production

process and alignment fluctuation.

BRIEF DESCRIPTION OF THE DRAWINGS

20   In the accompanying drawings:

Figs. 1A, 1B, 1C, 1D, and 1E are sectional

views showing a manufacture procedure in a first

embodiment of a solid state image pickup element of

the present invention;

25   Fig. 2 is a top view showing the positional

relation between color filters that are formed by

split exposure in accordance with the present

invention;

Figs. 3A, 3B, 3C, 3D, and 3E are sectional views showing a manufacture procedure in a second embodiment of a solid state image pickup element of

5   the present invention;

Figs. 4A and 4B are diagrams of a relevant part enlarged to illustrate an example of the shape of color filters in the solid state image pickup element shown in Figs. 3A, 3B, 3C, 3D and 3E;

10   Figs. 5A, 5B, and 5C are diagrams of a relevant part enlarged to illustrate another example of the shape of color filters in the solid state image pickup element shown in Figs. 3A 3B, 3C, 3D and 3E;

Figs. 6A, 6B, 6C, 6D, and 6E are sectional

15   views showing a manufacture procedure in a third embodiment of a solid state image pickup element of the present invention;

Figs. 7A, 7B, and 7C are top views showing the structure of a solid state image pickup element

20   according to a fourth embodiment of the present invention;

Fig. 8 is a side sectional view showing the structure of a conventional solid state image pickup element;

25   Figs. 9A, 9B, 9C, and 9D are side sectional views illustrating a procedure of forming conventional color filters that are shown in Fig. 8;

Fig. 10 is a side sectional view showing light path examples for light which enters a solid state image pickup element from an image pickup object;

Figs. 11A and 11B are diagrams of a relevant

5   part enlarged to show mispositioning of color filters and an example of the shape of a first planarization film in the conventional solid state image pickup element shown in Figs. 9A 9B, 9C and 9D;

Fig. 12 is a top view showing the positional

10   relation between conventional color filters formed by split exposure; and

Fig. 13 is a top view showing the positional relation between conventional color filters formed by split exposure.

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DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to the accompanying drawings, the present invention is described below.

First Embodiment

20   Figs. 1A to 1E are sectional views showing a manufacture procedure in a first embodiment of a solid state image pickup element of the present invention.

The solid state image pickup element shown in

25   Figs. 1A to 1E has a pixel pitch of 9 μm and color filters are arranged in accordance with the Bayer pattern similar to the conventional solid state image

pickup elements shown in Figs. 12 and 13. The

structure of this solid state image pickup element is

identical with that of the conventional solid state

image pickup element shown in Fig. 8 except the

5   shapes of the color filters, and therefore a

description of the identical part is omitted here.

In a solid state image pickup element

manufacturing method of this embodiment, the first

step is to apply negative color resist with, for

10   example, a green (G) pigment dispersed therein to a

surface of a first planarization film 4 as shown in

Fig. 1A. Then a mask which blocks light except where

G filters are to be formed is placed for irradiation

with ultraviolet rays having a wavelength of, for

15   example, 365 nm, and for subsequent development.

Thus G filters 3G are formed on the first

planarization film 4. The pattern of the G filters

3G in this embodiment measures 9.0 μm at the bottom

portion (on the first planarization film side).

20   Next, as shown in Fig. 1B, negative color

resist 3A with a red (R) pigment dispersed therein is

applied to the entire top surface of the first

planarization film 4 while covering the G filters 3G.

Then a mask which blocks light except where R filters

25   (each denoted by 3R) are to be formed is placed for

irradiation with ultraviolet rays having a wavelength

of, for example, 365 nm.

The mask used in this ultraviolet irradiation
has a 8.5 μm square transmissive portion positioned,
for example, 0.25 μm away from the edges of a region
surrounded by the G filters 3G as shown in Fig. 1B
5   where there is no fear of the R filter 3R overlapping
the G filters 3G even when the mask is mispositioned.

If the ultraviolet irradiation energy is small
during formation of the R filter 3R, the R filter 3R
after development is isolated like an island in the
10   region surrounded by the G filters 3G as shown in Fig.
1C. If the ultraviolet irradiation energy is
increased (over-exposure), the R filter 3R is
gradually widened in response to an increase in
irradiation energy until the R filter 3R comes into
15   contact with the edges of the G filters 3G as shown
in Fig. 1D. As the ultraviolet irradiation energy is
further increased, the R filter 3R is increased in
size until the region surrounded by the G filters 3G
is filled with the R filter 3R. The R filter 3R is
20   almost completely embedded in the region surrounded
by the G filters 3G as shown in Fig. 1E if the
irradiation energy is optimized.

Once the R filter 3R comes into contact with
the edges of its adjacent G filters 3G, an increase
25   in size of the R filter is restrained irrespective of
an increase in irradiation energy. Therefore, the R
filter 3R does not climb over the G filters 3G. This

shows that the size of the R filter 3R is defined by the shape and size of the G filters 3G.

Therefore, according to the solid state image pickup element manufacturing method of this embodiment, a color filter can be formed stably with its size and position regulated by the sizes of adjacent color filters previously formed and no void is created even when there are fluctuation in production process and alignment fluctuation.

If this embodiment is applied to a process of manufacturing color filters of a solid state image pickup element by split exposure, voids between adjacent color filters in one exposure region can be kept approximately identical to voids in the other exposure region (a first exposure region and a second exposure region) as shown in Fig. 2 even when the process fluctuates from one exposure shot to another. Therefore, image non-uniformity between exposure regions in a picked-up image can be reduced.

An image has been picked up using the solid state image pickup element of this embodiment and inspected to find no visible streaks of image non-uniformity in portions of the picked-up image that correspond to interfaces of exposure regions even though split exposure has been employed in the color filter manufacturing process.

Second Embodiment

Figs. 3A to 3E are sectional views showing a manufacture procedure in a second embodiment of a solid state image pickup element of the present invention.

5   The solid state image pickup element shown in Figs. 3A to 3E, similarly to the first embodiment, has a pixel pitch of 9 µm and color filters are arranged in accordance with the Bayer pattern.

In a solid state image pickup element

10   manufacturing method of the second embodiment, the first step is to apply negative color resist with, for example, a green (G) pigment dispersed therein to a surface of a first planarization film 4 as shown in Fig. 3A. Then a mask which blocks light except where

15   G filters 13G are to be formed is placed for irradiation with ultraviolet rays having a wavelength of, for example, 365 nm, and for subsequent development. Thus G filters 13G are formed on the first planarization film 4.

20   In this embodiment, the G filters 13G are exposed to light through ultraviolet irradiation of varying intensity. To elaborate, the exposure contrast is lowered at edges of a region to be exposed to light, so that the pattern of the G

25   filters 13G measures 9.1 µm at the bottom portion (on the first planarization film side). In this case, the edges of the G filters 13G are tapered as shown

in Fig. 3A. The exposure contrast at the edges of
the exposure region can be lowered by shifting the
focus of exposure light.

Next, as shown in Fig. 3B, negative color

5   resist 13A with a red (R) pigment dispersed therein
is applied to the entire top surface of the first
planarization film 4 while covering the G filters 13G.
Then a mask which blocks light except where R filters
(each denoted by 13R) are to be formed is placed for

10   irradiation with ultraviolet rays having a wavelength
of, for example, 365 nm.

In the second embodiment, the width of a region
surrounded by the G filters 13G is 8.9 μm and an area
of this region which is at a given distance from the

15   edges of the G filters 13G is irradiated with
ultraviolet rays. Specifically, ultraviolet
irradiation is performed on a 8.4 μm square region
which is 0.25 μm inside from the edges of the G
filters 13G, where the R filter 13R does not overlap

20   the G filters 13G even when the mask is mispositioned
in forming the R filter 13R.

If the ultraviolet irradiation energy is small
during formation of the R filter 13R, the R filter
13R after development is isolated like an island in

25   the region surrounded by the G filters 13G as shown
in Fig. 3C. If the ultraviolet irradiation energy is
increased, the R filter 13R is gradually widened in

response to an increase in irradiation energy until the R filter 13R comes into contact with the edges of the G filters 13G as shown in Fig. 3D. As the ultraviolet irradiation energy is further increased,

5 the R filter 13R is increased in size until the region surrounded by the G filters 13G is filled with the R filter 13R. The R filter 13R is almost completely embedded in the region surrounded by the G filters as shown in Fig. 3E if the irradiation energy

10 is optimized. The edges of the R filter 13R are tapered in a manner reverse to how the G filters 13G are tapered as shown in Fig. 3E, thereby adapting the shape of the R filter 13R to the shape of the G filters 13G.

15 In this embodiment, with the edges of the G filters 13G tapered, a void or other defect hardly takes place in the formation of the R filter 13R in the portion where the R filter 13R is embedded even when the edges of the G filters 13G are locally

20 deformed. The overlapping amount of tapered portions of adjacent color filters is desirably 0.1 μm or more in order to prevent transmission of light from a void without fail.

The edges of each color filter are tapered in

25 this embodiment. Therefore no void is created in the juncture between adjacent color filters.

Accordingly, if this embodiment is applied to a

process of manufacturing color filters of a solid
state image pickup element by split exposure, voids
between adjacent color filters in one exposure region
can be kept approximately identical to voids in the
5   other exposure region even when the process
fluctuates from one exposure shot to another.

If the ultraviolet irradiation energy is not
enough during formation of the R filter 13R in this
embodiment, a small void is created on the top faces
10   of the color filters at the edges as shown in Fig. 4A.
On the other hand, if the ultraviolet irradiation
energy is higher than necessary in forming the R
filter 13R, a slight overlapping takes place on the
top faces of the color filters at the edges as shown
15   in Fig. 4B. However, these structures shown in Figs.
4A and 4B can also prevent the ingress of light from
a void between adjacent color filters 13, thereby
reducing surface irregularities of a second
planarization film 2 that is formed on the color
20   filters 13. Accordingly, the amount of incident
light that reaches the photoelectric conversion
portion does not fluctuate among pixels.

It is not necessary for the color filters 13 in
this embodiment to have tapered or reversely tapered
25   edges shown in Fig. 5A. The edges of the color
filters 13 can have any shape as long as adjacent
color filters are fitted to each other, and may be

wedgelike as shown in Figs. 5B and 5C. These shapes can be obtained by changing the exposure contrast at the edges of a region of color resist to be exposed to light.

5 Third Embodiment

Figs. 6A to 6E are sectional views showing a manufacture procedure in a third embodiment of a solid state image pickup element of the present invention.

10 The solid state image pickup element shown in Figs. 6A to 6E, similarly to the first embodiment, has a pixel pitch of 9 μm and color filters are arranged in accordance with the Bayer pattern.

In a solid state image pickup element 15 manufacturing method of the third embodiment, similarly to the first embodiment, the first step is to apply negative color resist with, for example, a green (G) pigment dispersed therein to a surface of a first planarization film 4. Then a mask which blocks 20 light except where G filters 23G are to be formed is placed for irradiation with ultraviolet rays having a wavelength of, for example, 365 nm, and for subsequent development. Thus G filters 23G are formed on the first planarization film 4 as shown in 25 Fig. 6A. In this embodiment, the G filters 23G are exposed to light through ultraviolet irradiation of varying intensity. To elaborate, the exposure

contrast is lowered at edges of a region to be exposed to light, so that the pattern of the G filters 23G measures 9.1 μm at the bottom portion (on the first planarization film 4 side). In this case,

5   the edges of the G filters 23G are tapered as shown in Fig. 6A. The exposure contrast at the edges of the exposure region can be lowered by shifting the focus of exposure light.

Next, as shown in Fig. 6B, negative color

10 resist 23A with a red (R) pigment dispersed therein is applied to the entire top surface of the first planarization film 4 while covering the G filters 23G. Then a mask which blocks light except where R filters (each denoted by 23R) are to be formed is placed for

15 irradiation with ultraviolet rays having a wavelength of, for example, 365 nm.

Similar to the second embodiment, the width of a region surrounded by the G filters 23G is 8.9 μm and, in the third embodiment, the region surrounded

20 by the G filters 23G is exposed to light through ultraviolet irradiation of varying intensity (See Fig. 6B). To elaborate, the R filter 23R is formed by ultraviolet irradiation with the exposure contrast lowered at the edges of the region to be exposed to

25 light.

If the ultraviolet irradiation energy is small during formation of the R filter 23R, the R filter

23R after development is isolated like an island in the region surrounded by the G filters 23G as shown in Fig. 6C.

On the other hand, if the ultraviolet

5   irradiation energy is increased, the R filter 23R is gradually widened in response to an increase in irradiation energy until the R filter 23 R comes into contact with the edges of the G filters 23G as shown in Fig. 6D. As the ultraviolet irradiation energy is

10   further increased, the R filter pattern is increased in size until the region surrounded by the G filters 23G is filled with the R filter 23R.

Accordingly, the R filter 23R is almost completely embedded in the region surrounded by the G

15   filters 23G as shown in Fig. 6E if the irradiation energy is optimized.

The edges of each color filter 23 are tapered in this embodiment, similarly to the second embldiment. Therefore no void is created in the

20   juncture between adjacent color filters.

Accordingly, if this embodiment is applied to a process of manufacturing color filters of a solid state image pickup element by split exposure, voids between adjacent color filters in one exposure region

25   can be kept approximately identical to voids in the other exposure region even when the process fluctuates from one exposure shot to another.

The second and third embodiments described above employ a method of shifting the focus of exposure light from the mask surface to lower the exposure contrast at edges of an exposure region.

5 Alternatively, the exposure contrast at edges of an exposure region may be lowered by changing the transmittance in edges of a mask in stages (by gradating the optical density) and this method too can provide excellent results.

10 Examples of forming R filters after formation of G filters are described in the first through third embodiments. However, the order of forming color filters is not limited thereto and G filters, R filters, and blue color filters (hereinafter referred

15 to as B filters) can be formed in an arbitrary order. In such case, one of the methods by which R filters are formed in the first through third embodiments is employed to form two color filters that are to be formed later.

20 Fourth Embodiment

Figs. 7A to 7C are top views showing the structure of a solid state image pickup element according to a fourth embodiment of the present invention.

25 As shown in Fig. 2, the exposure contrast is lower in corners of a color filter than along sides of the color filter and therefore the pattern shape

is likely to vary around color filter corners due to
fluctuation in production process.

This embodiment eliminates a void by filling
color filter corners where the exposure contrast is
5   low with one of two adjacent color filters as shown
in Figs. 7A to 7C.

To eliminate a void in a corner of a color
filter, color resist is exposed to light using a mask
with a transmissive portion of which each corner has
10   a minute pattern for filling a void.

Image non-uniformity between exposure regions
in a picked-up image due to void fluctuation among
color filter corners can be reduced by thus filling a
corner of a color filter with an adjacent color
15   filter. If the fourth embodiment is combined with
one of the manufacture methods of the first through
third embodiments, voids between color filters are
completely eliminated and therefore image non-
uniformity between exposure regions in a picked-up
20   image can be reduced even more than in the first
through third embodiments.

Fig. 7A shows an example in which G filters are
formed in corners of every color filter. Fig. 7B
shows an example in which B filters are formed in
25   corners of every color filter. Fig. 7C shows an
example in which R filters are formed in corners of
every color filter.

Examples of a practical mode of the present invention are listed below.

[Practical mode 1]

A method of manufacturing a solid state image pickup element with color filters of plural colors formed of negative type color resist, including:

applying negative type color resist for forming first color filters onto an entire surface of a given film;

forming the first color filters by irradiation of given portions with exposure light and by subsequent development;

applying negative type color resist for forming second color filters onto the entire surface of the first color filters while covering the first color filters; and

forming the second color filters by irradiating an area smaller than a region that is surrounded by the first color filters with exposure light and by subsequent development.

[Practical mode 2]

The method of manufacturing a solid state image pickup element as described in practical mode 1, in which the region to be exposed to light during formation of the second color filters is overexposed at edges compared to standard exposure conditions.

[Practical mode 3]

The method of manufacturing a solid state image pickup element as described in practical mode 1, in which, compared to standard exposure conditions, an exposure contrast is low at any of edges of a region

5   to be exposed to light during formation of the first color filters and edges of a region to be exposed to light during formation of the second color filters.

[Practical mode 4]

The method of manufacturing a solid state image

10   pickup element as described in practical mode 2 or 3, in which, compared to standard exposure conditions, an focus point of the exposure light is shifted at any of the edges of the region to be exposed to light during formation of the first color filters and the

15   edges of the region to be exposed to light during formation of the second color filters.

[Practical mode 5]

The method of manufacturing a solid state image pickup element as described in any one of practical

20   modes 2 to 4, in which an optical density of the exposure light is gradated at any of the edges of the region to be exposed to light during formation of the first color filters and the edges of the region to be exposed to light during formation of the second color

25   filters.

[Practical mode 6]

A solid state image pickup element with color

filters of plural colors, in which one of adjacent color filters is tapered at edges while the other color filter is reversely tapered at the edges, allowing the adjacent color filters to fit to each

5   other.

[Practical mode 7]

A solid state image pickup element with color filters of plural colors, in which adjacent color filters are wedged at edges, allowing the adjacent

10   color filters to fit to each other.

[Practical mode 8]

The solid state image pickup element as described in practical mode 6 or 7, in which at least one of the adjacent color filters is formed in

15   corners of the adjacent color filters.

[Practical mode 9]

The solid state image pickup element as described in any one of practical modes 6 to 8, in which the overlapping amount of the adjacent color

20   filters is 0.1 μm or more.

The present invention is constructed as described above, and has the following advantages.

A color filter can be formed stably with its size and position regulated by the sizes of adjacent

25   color filters and no void is created even when there is fluctuation in production process and alignment fluctuation.

If this embodiment is applied to a process of
manufacturing color filters of a solid state image
pickup element by split exposure, voids between
adjacent color filters in one exposure region can be

5   kept approximately identical to voids in the other
exposure region even when the process fluctuates from
one exposure shot to another. Therefore, image non-
uniformity between exposure regions in a picked-up
image can be reduced.

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